arXiv:hep-th/0410201v2 21 Oct 2004

SUPERSYMMETRY, NATURALNESS AND THE LANDSCAPE*

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We argue that the study of the statistics of the landscape of string vacua provides the first potentially predictive – and also falsifiable – framework for string theory. The question of whether the theory does or does not predict low energy supersymmetry breaking may well be the most accessible to analysis. We argue that low energy – possibly very low energy – supersymmetry breaking is likely to emerge, and enumerate questions which must be answered in order to make a definitive prediction.

1. Introduction: Beyond the Standard Model in the late 20th Century

In the last few years, evidenced has accumulated that there are a vast number of metastable solutions of string theory. This collection of states has been dubbed the "landscape" of string vacua.[1] This development has, for understandable reasons, lead to a great deal of criticism – perhaps complaining would be a more accurate description. Complaining about this landscape is not a particularly productive activity; it either exists as part of the underlying theory of quantum gravity, or it does not. If it does, its implications must be confronted. I have been a vocal skeptic[2,3] about the existence of the landscape, and still have doubts, but the evidence is impressive, and the possibility demands serious attention.

Complaining is one of the great pleasures of life, though, so let's examine the complaints. Those who scoff at the landscape complain principally that the landscape lacks predictivity. I will try to argue that, at least compared with string theory as we have practiced it for the past twenty years, *the*

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landscape is the first predictive framework we have encountered. It may be far less than we hoped for[a], but it may answer some of the questions which particle physicists have struggled with for almost three decades. To this end, I would put forward the following model of what physicists, thinking about what may lie beyond the Standard Model, did for the quarter century after the Standard Model was established. I would divide us into two classes:

(1) Model Builders: Model builders explored an infinitely large space of possible field theories. (A *very* large infinity if allow extra dimensions, non-renormalizability...) In this exploration, there were a few guideposts and rules: phenomenological constraints, *naturalness, simplicity.*

(2) String Theorists: String theorists confronted the existence of a huge number of classical solutions. Most of these bear no resemblance to the world around us. At the quantum level, it is hard to exhibit solutions with $N < 2$ supersymmetry. Simple, general arguments showed that it would be difficult to find stable, non-susy (broken susy) vacua in any controlled approximation. There was also no (persuasive) clue to understanding the small value of the cosmological constant. For a theory which by its nature is a theory of gravity, this proved an enormous obstacle.

In response to this situation, many string theorists simply dropped any attempt to think about string phenomenology. Those who persisted were forced to adopt one of two approaches:
a. Look for realistic models at weak coupling. Assume these are selected, and that the features they exhibit at weak coupling survive at strong coupling (or that the couplings are accidentally weak).
b. Look at generic features of string models (susy, axions, large dimensions), and hope these are somehow general, reflecting properties of some stable quantum system(s).

Understand that I am not criticizing those working in these frameworks; I have been a practitioner of all of these approaches. But in thinking about the landscape, it is helpful to keep in mind what we actually do. One lesson, well known to model builders, should be kept in mind: almost all models

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[a]Some leading physicists have forcefully argued to me that the landscape, on the one hand, is quite possibly the correct picture of the fundamental theory of nature, and on the other, quite disappointing.

are wrong. We will see that the landscape can be a guide to model building – one in which notions of naturalness, simplicity and the like are sharp. From the perspective of a model builder, it is a new game which is fun; at worst, it is, like most approaches, wrong.

From a string theory perspective, I will argue that for the first time the landscape provides a predictive set of rules. There are a few questions which we will not attempt to answer: the value of the cosmological constant, probably the value of the weak scale and certain couplings; we will have to write these quantities off as "anthropic" or "environmental." But the fact that we can even accommodate the observed values of these quantities is something new and exciting. Some might argue that *the most disappointing aspect of the anthropic solution of these problems is perhaps that it is so pedestrian.* But this is the first time in string theory we have had any way of understanding these seemingly fundamental questions. Perhaps there is a deeper, more beautiful answer, but, lacking that, it doesn't make sense to ignore one which we have.

2. An Overview of The Flux Landscape

The idea of a discretuum of states, which might provide an understanding of the small value of the cosmological constant, has a rather long history.[4,5,6,7] But until the work of Kachru, Kallosh, Linde and Trived(KKLT),[31] while there were a variety of scenarios, there were no persuasive constructions in anything resembling a systematic approximation.   KKLT exhibited metastable points in the moduli effective potential, in controlled (or nearly controlled) approximations. These states were both dS and AdS, with and without supersymmetry. Their work strongly indicated the existence of a vast number with all moduli stabilized. There are many questions one can raise about this analysis. Most importantly, all of these states must be understood cosmologically. Somewhere in their past or future they have various singularities, and we don't know how or whether these might be resolved. Moreover, the notion of connectedness in this landscape is, at best, obscure.[3] But it is not clear that these obstacles are insurmountable,[9] and few physicists – even those who find the landscape repugnant – seem to take these objections seriously. This is, in part, because they apply to virtually any string theory configuration with less than four supersymmetries. Still, the possibility that the landscape may not exist should be kept in mind.

Accepting, at least provisionally, the existence of the landscape, the

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nature and goals of string theory (fundamental physics) are different than we previously imagined. In this vast "landscape", one can't hope to find "the state" which describes our universe. Our interest shifts to the statistics of these states.[34,?,12] Nor can our goal to be predict all of the features of nature with arbitrary precision. But there is a very real possibility of predictions, based on finding *correlations* among properties of the states. One also has the possibility for falsification: typical states in the landscape might be inconsistent with experiment.

We don't yet all we need to know to make predictions. But what is particularly remarkable is that, thanks to the work of a number of researchers, some features of the statistics of the landscape are starting to emerge. We can already do some prototype calculations, and can pose sharp questions, which can plausibly be answered.

One question looks particularly important and quite possibly accessible: does this framework predict low energy supersymmetry? If so, does it suggest a particular scale for the breaking? I will focus on this possible prediction for future experiments, as well as on one possibility for falsification:

- The possibility that cosmological constant + the hierarchically small value of the weak scale imply low energy supersymmetry.
- The problem that θ_{qcd} seems, within the landscape, to be a uniformly distributed random variable.[3,13]

3. Review of the KKLT Construction

In this section, we briefly review the KKLT construction. We focus on a particular case: orientifolds of IIB theory on a Calabi-Yau space. In such theories, there are a variety of moduli: complex structure moduli (z_a), Kahler moduli (ρ_i), and the axion-dilaton multiplet: $\tau = \frac{1}{g_s} + ia$

IIB theory has RR and NS-NS three-index antisymmetric tensor fields, F, H. Solutions of the string equations exist on CY spaces with non-trivial, quantized fluxes, characterized by integers:

$$\int_{\Sigma_i} H = M_i \qquad \int_{\Sigma_i} F = K_i$$

Here the integrals are over three-cycles, Σ_i. In general, there are many (100's) of possible cycles. There are also many possible values of the integers K and M. For generic fluxes, the z_a's and τ are fixed in these solutions. This has a low energy explanation: in the presence of flux, there is a non-

trivial superpotential:[14] $W(z, \tau)$, at the leading order in the α' (large radius) expansion.

An interesting example, which illustrates some features which will be important in our later discussion was provided by Giddings, Kachru and Polchinski (GKP),[15]. They studied a Calabi-Yau space near a conifold point in the moduli space, focussing on the modulus, z, which measures the distance from the conifold point. With fluxes on collapsing three cycles at this point, one finds both stabilization and warping. The superpotential is given by:

$$W = (2\pi)^3 \alpha' (M\mathcal{G}(z) - K\tau z) \tag{1}$$

where M, K: fluxes.

$$\mathcal{G}(z) = \frac{z}{2\pi i} \ln(z) + \text{ holomorphic.} \tag{2}$$

This has a supersymmetric minimum if

$$D_z W = \frac{\partial W}{\partial z} + \frac{\partial K}{\partial z} W = 0 \tag{3}$$

These equations are solved by:

$$z \sim \exp(-\frac{2\pi K}{M g_s}) \tag{4}$$

If the ratio N/M is large, then z is very small. The corresponding space can be shown to be highly warped (in the sense of Randall and Sundrum.[16])

$$W_o = < W >, \tag{5}$$

in this example, is exponentially small.

Including additional fluxes, it is possible to fix other complex structure moduli, including τ. GKP [15] provided an example with:

$$W = (2\pi)^3 \alpha' [M\mathcal{G}(z) - \tau(Kz + K'f(z))] \tag{6}$$

$$D_\tau W = \frac{\partial W}{\partial \tau} + \frac{\partial K}{\partial \tau} W = 0$$

for

$$\bar{\tau} = \frac{M\mathcal{G}(0)}{K'f(0)} \qquad W_o = 2(2\pi)^3 \alpha' M\mathcal{G}(0)$$

Note that in this example, while z is still exponentially small, and the space is highly warped, W_o is no longer exponentially small. It is W_o which will be particularly important in what follows.

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Typically, there are many additional moduli and fluxes. and a possible huge number of states. In these states, W_o is essentially a random variable. Small W_o corresponds to approximate $N = 1$ supersymmetry, and in theses cases on can describe the low energy physics by a supersymmetric effective lagrangian.

What is the low energy physics? In the discussion of GKP,[15] the radii (Kahler moduli) are not fixed. For large R, discrete shift symmetries guarantee that any dependence in W on the $\rho_i \sim R^3$ is exponentially small, $e^{-c\rho}$. Here KKLT made a crucial observation: exponentially small corrections,

$$W = W_o + e^{-c\rho} \qquad (7)$$

may arise from various sources (gluino condensation, membrane instantons...) The resulting potential has supersymmetric (AdS) solutions with

$$D_\rho W = \frac{\partial W}{\partial \rho} + \frac{\partial K}{\partial \rho} W = 0 \qquad \rho \approx -\frac{1}{c} \ln(W_o). \qquad (8)$$

Douglas[34] and Kachru[17] gave heuristic arguments, subsequently verified by Douglas and Denef,[18] that suggest that the distribution of W_o should be essentially flat as a random variable. Because of the vast number of possible choices of flux, this means that there are a vast number of states in which all of the moduli are fixed, with unbroken supersymmetry, in a (more or less) controlled approximation.

KKLT were particularly interested in obtaining dS spaces, and suggested a further subset of all states would have supersymmetry broken: vacua with $\overline{D3}$ branes located at the ends of warped throats.

It is worth pausing to estimate how many states there are. Consider a lattice of integers, (the flux lattice), with dimensionality K. Denote the vectors in the lattice by $\vec{n}$. Take $\vec{n}^2 \leq L$ (L is the integer which appears in the tadpole cancellation condition; that for supersymmetric states, this translates into a condition along the lengths of vectors can be shown, e.g., by the methods of Douglas and Denef). If one then just evaluates the volume of a K dimensional sphere of radius $\sqrt{L}$, one expects for the number of (nearly) supersymmetric states:

$$\mathcal{N}_{susy} \sim \frac{L^{K/2}}{\Gamma(K/2)}.$$

Surveying known Calabi-Yau spaces, one has many examples with

$$L \sim 1000's \qquad K \sim 100's.$$

For low energy observers, physics is different in each of these states. Gauge groups, coupling constants and the like all vary. *The cosmological constant*, in particular, is a random variable in these 10^{1000}(?!) states.

So, again, the problem is not to find "the state" which describes our universe; this is hopeless. Instead, one needs to study statistics of these states, and learn the distribution of gauge groups, matter content, couplings, cosmological constant, etc.

4. Experimental Predictions from the Landscape

With this counting, however, we have the first striking observation: if the landscape is correct, string theory can accommodate, if not explain, the small value of the cosmological constant. In this setup, the cosmological constant is essentially a random variable. We will talk about its distribution shortly, but if there are 10^{1000} states, say, there are a huge number with cosmological constant close to that observed.

4.1.   What data should we use (Priors)?

Given that there is a distribution of low energy parameters, we could only hope to predict them all from first principles if we had some cosmological principle which would select one state. Our working assumption is that, while cosmology is certainly an important part of this story, all of the states of the landscape are more or less equally likely.[b] One approach, then, would be to take all measured parameters of Standard Model and cosmology as input parameters, and ask what values of other quantities are typical, given these priors. This viewpoint has been advocated by a number of authors, but I would argue against it on several grounds. First, consider an analogous problem in statistical mechanics. Suppose one had worked out the theory of gases, and then went to examine the air in a closed room, and discovered that at that instant, 3/4 of the atoms were in a small corner. We could simply accept this. After all, this is as much an allowed state in the ensemble as any other. Still, it is very atypical. We could quantify this by asking for the expectation value of the density, and studying fluctuations.

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[b]More precisely, we are assuming that if, say, states with more e-foldings of inflation are favored over states with less, we are actually assuming the number of e-foldings is not highly correlated with quantities such as the number of generations or values of low energy couplings. This need not be the case; one could well imagine, for example, that supersymmetric states are more likely than generate inflation than non-supersymmetric states, if light scalars are crucial to inflation.

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Similar statements apply to the landscape. If we consider the cosmological constant, its mean value is of order M_p^4 (perhaps even larger). $\Lambda =$ is a special point; here the theory has Poincare-invariant solutions.[c] The probability of observing a very small cosmological constant, such as we see, is extremely tiny. So it is necessary to explain this fact. Similarly, we can ask about the values of other quantities, like θ_{qcd}. Again, in the landscape, the mean value, relative to the CP conserving point, appears to be of order one, and the distribution uniform. So finding a value very close to the special point is surprising and requires some rational explanation.

Of course, in the case of θ, we can at least imagine some microscopic explanation. It could be that in some large subset of states in the landscape, there are axions, and that these states are favored by some other considerations (see below). Perhaps approximate flavor symmetries play some role. For the cosmological constant, we know of nothing comparable.

4.2. *The Anthropic Principle*

Within the landscape, we have argued that there are likely to be many states with cosmological constant similar to what we observe. But we have also argued that the observed value is very surprising; it is not a simple piece of data. This is, in fact, the most persuasive setting in which to implement the (weak) anthropic solution of the cosmological constant problem.[4,?,20]

Usually, mention of the anthropic principle brings handwringing about the end of science. But, for better or worse, the anthropic explanation is arguably the most plausible proposal we have to understand the small value of Λ. *I will argue that we confront a Faustian bargain. If we adopt the anthropic viewpoint, we are lead to the first predictive framework for string theory.*

This statement requires explanation on several counts. First, I have to say that I do not know how to implement the anthropic principle. It is nearly impossible to say: the weak anthropic principle (the requirement that we find ourselves in an environment or neighborhood which can support life) requires the cosmological constant to be..., the fine structure constant to be... the strength of inflationary fluctuations to be... The problem is simply too complicated.[21,22,3]

Instead, for the moment, I will adopt a more pragmatic view: I am willing to impose, as priors, any quantity which might plausibly be anthropic

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[c]A more precise analogy to the statistical mechanical model would be provided by asking the probability of finding universes which admit a significant degree of complexity.

– but not those which cannot be. Examples of the former include: the gauge group, Λ, α, Λ_{qcd}, m_e, m_u, m_d, the dark energy density. Examples of quantities which are probably not anthropic are the value of θ_{qcd} and heavy quark masses and mixings.

These rules may seem overly generous, but they leave open very real possibilities for prediction and for falsification. With mild (in my view) assumptions about the distribution of states and two anthropically motivated priors, the observed small cosmological constant and Higgs mass lead to a prediction of low energy supersymmetry. These assumptions are true of a small piece of the landscape which as already been studied, but may not be true more generally; *what is important is that they can be checked.*

They also provide a possible route to more immediate falsification. Consider θ_{qcd}; it has hard to offer any plausible anthropic explanation of its small value. In the flux discretuum, on the other hand, it appears to be a random variable with a roughly uniform distribution. Some rational explanation (axions? $m_u = 0$) is required. The mechanism must be typical of the states which satisfy other selection criteria in the landscape, or landscape idea is false. One can speculate on possible explanations. For example, axions might constitute the dark matter, and vacua with axions might be selected anthropically. But it is not clear that even this yields a small enough θ.

5. Supersymmetry or Not

There are some distributions which we do know, thanks to the work of Douglas and collaborators and Kachru and collaborators.[18,33] Two are relevant to the question of low energy supersymmetry.

(1) W_o. The distribution of W_o, as a complex variable, is known at least in some cases to be roughly uniform. KKLT gave a crude argument for this, which is supported by the results of Douglas and Denef. Think of $W_o = \sum a_i n_i = \vec{a} \cdot \vec{n}$ where $\vec{a}$ is independent of the fluxes (this is the rough part of the argument). This gives, at small W_o, a uniform distribution of both Re W_o and Im W_o. So

$$\int d^2 W_o P(W_o)$$

with $P(W_o)$ approximately uniform.

(2) $\tau = \frac{1}{g} + ia$. Since the IIB theory has an $SL(2Z)$ symmetry, one

might expect

$$P(\tau)\frac{d^2\tau}{(\text{Im } \tau)^2}$$

with $P(\tau)$ roughly constant. Indeed, this is what Douglas and Denef find. It corresponds to gauge coupling constants distributed uniformly with g^2.

5.1. *Three branches*

KKLT established that for some fraction of flux choices, one can exhibit metastable states in a more or less systematic approximation. In most states, no such analysis is possible, but in thinking about statistics, it may still sometimes be useful to use the supergravity lagrangian and examine its solutions. At this level of analysis, analysis, there are three important branches of the flux landscape

(1) Broken supersymmetry in the leading approximation.
(2) Unbroken supersymmetry, $W_o \neq 0$.
(3) Unbroken susy, $W_o = 0$.

Douglas and Denef suggest that the number of states on the first branch, if one simply looks for stationary points of the leading order potential, is infinite. In fact, it is rather easy to exhibit infinite sequences of gauge-invariant, non-supersymmetric states.[24] Douglas and Denef argue that one should cut off the sum over states in this case. If one simply requires either that the α' corrections not be large, or that the states be long-lived, one must cut off the sum at small flux number ($\mathcal{O}(1)$).[24] So there is no evidence from this type of counting that there are vastly more non-supersymmetric than supersymmetric states. On the other hand, by their very nature, any would-be non-supersymmetric states are difficult to explore, and it is quite possible that we are not looking in the right place[d].

If it should turn out that there are vastly more non-susy than susy states, this can overwhelm the usual naturalness arguments for susy.[25,26] If the non-supersymmetric branch should turn out to dominate, this would be particularly disappointing, and not merely for supersymmetry proponents. As the arguments of Douglas and Susskind make clear, there is unlikely to be any small parameter in such a case. Environmental selection would simply select from a vast, complicated and essentially inaccessible ensemble. It

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[d]This point has been emphasized to me quite cogently by Silverstein

is hard to see how any prediction should emerge. For example, the scenario of Arkani-Hamed and Dimopoulos[27] can be argued not to predominate in the landscape.[24]

Apart from arguments about the landscape, *nature* provides us with reasons to hope that the picture is not so bleak. As we have stressed, there are many features of the Standard Model which appear neither random nor anthropic. Some questions must have rational explanation.

6. The Supersymmetric, $W \neq 0$ Branch

The supersymmetric, $W \neq 0$ branch, is distinctly more interesting. While supersymmetry is unbroken to all orders in ρ, there is no reason to expect that this is exact. Low energy dynamics are likely to break supersymmetry in a finite number of states.[e] Calling $\mathcal{M}$ the scale of susy breaking ($m_{3/2} = \frac{\mathcal{M}^2}{M_p}$):

$$\mathcal{M}^4 = e^{-c\frac{8\pi^2}{g^2}} \qquad (M_p = 1) \qquad (9)$$

The uniform distribution in g^2 then translates into a distribtion of $\mathcal{M}^2$ or $m_{3/2}^2$:

$$P(m_{3/2}) = \frac{dm_{3/2}^2}{m_{3/2}^2(-\ln(m_{3/2}^2))} \qquad (10)$$

which is roughly uniform with the logarithm of the energy scale.

On this branch, small cosmological constant and the facts just mentioned do not by themselves predict low energy supersymmetry. We can ask: how many states have cosmological constant smaller than a give value? As a simplified model we write for the cosmological constant:

$$\Lambda = \mathcal{M}^4 - 3|W_o|^2 \qquad (11)$$

so that the fraction of states with cosmological constant less than Λ_o is given by:

$$F_1(\Lambda < \Lambda_o) = \int_0^{W_{\max}} d^2W_o \int_{\ln(|W_o|^2)}^{\ln(|W_o|^2+\Lambda_o)} d(g^{-2})g^4 \qquad (12)$$

$$\approx \int_0^{W_{\max}} d^2W_o \frac{\Lambda_o}{|W_o|^2}(-1/\ln(W_o))^2$$

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[e]The $\overline{D3}$ effects of KKLT are quite possibly dual to these; in any case, as will be explained elsewhere,[24] the counting of these states is similar to that which we perform now.

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So requiring small cosmological constant gives a distribution of $m_{3/2}$ flat on a log scale. But now imposing the value of the weak scale as an additional requirement favors supersymmetry breaking at the weak scale. This is just conventional naturalness. In terms of the probability analysis above, the Higgs mass will obtain contributions from many sources. Provided one has understood the smallness of the μ term (e.g. due to symmetries), for a Higgs mass well below the supersymmetry breaking scale, cancellations will be required; this corresponds in the landscape picture to the fact that the Higgs mass is small in a fraction of otherwise suitable states of order $\frac{m^2_{higgs}}{m^2_{susy}}$.

6.1. *The W=0 Branch: A very low energy breaking scenario*

There is a further subset of states with $W = 0$. These will arise in the subset of flux vacua with discrete R symmetries; they may also arise by accident.[38] Now one expects that both W_o and M_{susy} are generated dynamically. For example, an exponentially small W can be generated by gluino condensation in some other sector, which does not break susy. So now, like $\mathcal{M}$, the effective W_o is also distributed roughly uniformly on a log scale. Repeating our earlier counting,

$$F_1 \propto \int \frac{d^2 m_{3/2}}{m^4_{3/2}} \qquad (13)$$

So in this case, even before worrying about the value of the weak scale, breaking of supersymmetry at the lowest possible scale is significantly favored. Indeed, we now have to invoke the value of the weak scale to explain why the supersymmetry breaking scale is not extremely small. This is quite striking. In past phenomenological approaches to gauge mediation, no particular scale for susy breaking favored by theoretical (naturalness) considerations. In the landscape, it may well turn out that the scale is necessarily quite low. From the perspective of a model builder, this is an example of an added input to model building

6.2. *Possible Phenomenologies*

Each of these branches has a very different phenomenology.

- Whether the third, possibly most interesting branch, is favored depends on the price of discrete symmetries in the landscape (or $W =$

0 accidentally). Studies of this question will appear elsewhere.[29,24] Note that, from the point of view of obtaining the observed cosmological constant, the low energy scenario is "ahead" by a factor of order 10^{40}. Discrete symmetries may well cost more, but they may be necessary even in the $W \neq 0$ branch to account for proton stability and/or dark matter.

- If discrete symmetries are costly– the second branch, with higher energy breaking, as in gravity mediation is likely. A natural scenario,[35] has susy broken dynamically in a hidden sector. Gaugino masses are then generated through anomaly mediation.[30] The hierarchy among masses would arise because of the cosmological moduli problem, and the need to understand dark matter.[36f] Other scenarios, however, are possible.

- As we already said, if there are overwhelmingly more non-susy than susy states, this is quite disappointing, for it is very hard to see how one would make any connection with nature (but perhaps there are some clues: discrete symmetries and dark matter? neutrino masses?)

6.3. *How can we settle these questions?*

What is perhaps most exciting about this story is that we can imagine, with less than superhuman effort, answering these questions. We need to know:

- Are there, in the leading approximation, exponentially more non-supersymmetric than supersymmetric vacua? We have indicated that the answer to this question is likely to be no, but we certainly cannot claim to have proven such a statement. This would favor low energy supersymmetry.

- What is the price of discrete symmetries? In particular, we need to compare the cost of suppressing proton decay and (if necessary) obtaining a small μ term with the price of light Higgs without supersymmetry (10^{-36} or so), times the price of obtaining a stable, light dark matter particle (unknown, but probably not less than 10^{-36}), times the other tunings required to obtain an acceptable cosmology.

- Is there a huge price for obtaining theories with low energy dynamical supersymmetry breaking? Given the presumption that one can

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[f]This is similar to one of the scenarios discussed by Arkani-Hamed and Dimopoulos.[27]

  obtain a landscape of models with complicated gauge groups and chiral matter, it is hard to imagine that the price is enormous (in landscape terms). A part in a billion, for example, would likely lead to a prediction of low energy supersymmetry.

- Are unbroken discrete *R-symmetries* at the high scale common? If so, $\langle W \rangle$ must be generated dynamically at low energies in such vacua. In this case, we have seen that SUSY breaking at the lowest possible scale may be favored. R symmetries might be selected by other considerations as well, such as proton stability.
- Within the present knowledge of the landscape, non-supersymmetric conifolds appear to be the most promising alternative to low energy supersymmetry. What is the relative abundance of such states compared to supersymmetric states?

7. Conclusions

It seems likely that the landscape exists. If so, at the very least, it is a very large elephant in the closet. What are we to make of it? Clearly we need to explore it. *I have argued that for the first time, we may have a candidate predictive framework for string theory.*

- The study of the statistics of these states has begun. Many of the important questions seem accessible.
- The proposed set of rules seem likely to lead to predictions. The rules are subject to debate, but a sensible set of rules can probably be formulated.
- Low energy supersymmetry may well be one output. It is possible that we will be able to predict a detailed phenomenology.
- We have about three years!

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